



## Building Scalable Cisco Internetworks (BSCI)

### Intermediate System to Intermediate System (IS-IS)

<http://www.INE.com>

## What Is IS-IS?

- Intermediate System to Intermediate System
  - “Router to Router” communication
- Similar in many ways to OSPF
  - Standards Based IGP
    - ISO 10589
  - Link-State Protocol
    - Uses Dijkstra SPF Algorithm
  - “Classless” Protocol
    - Supports VLSM And Summarization

Copyright © 2009 Internet Network Expert, Inc  
[www.INE.com](http://www.INE.com)



## What Is IS-IS? (cont.)

- Major difference? ***Not an IP protocol***
- Part of the OSI Connectionless Network Service (CLNS) protocol stack
  - Connection-Mode Network Protocol (CMNP)
  - Connectionless Network Protocol (CLNP)
- IS-IS developed to route CLNS stack
  - Originally thought that CMNP/CLNP would replace TCP/IP
  - In short, it didn't ☺
- What is called IS-IS today is actually “Integrated IS-IS”, or IP extensions to IS-IS
  - RFC 1195 – “Use of OSI IS-IS for Routing in TCP/IP and Dual Environments”

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## OSPF & IS-IS Protocol Similarities

- Maintain active adjacencies with hellos
- Exchange LSPs to build topology graph
- Two-level hierarchy
  - OSPF Areas vs. IS-IS Levels
- Adjacency and flooding scalability over broadcast media
  - OSPF DR vs. IS-IS DIS
- NLRI Summarization
- Authentication

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## OSPF & IS-IS Protocol Differences

- OSPF
  - Generally enterprise focused
  - OSPF area designs typically take careful planning
  - Features, features, and more features
- IS-IS
  - Generally service provider focused
  - Typical flat designs require no planning
  - Stability as opposed to feature support
  - More easily extensible than OSPF
    - e.g. IPv6 via OSPFv3 vs. IS-IS TLVs
  - Theoretically more scalable than OSPF

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Link State Routing Review

- Form adjacency relationship with connected neighbors
- Exchange link attributes in form of Link State Advertisements (LSAs) / Link State Packets (LSPs) with neighbors
- Store copy of all LSAs in Link State Database (LSDB) to form a “graph” of the network
- Run Dijkstra algorithm to find shortest path to all links
- Since all routers have same LSDB, all SPF calculations are loop-free

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Forming IS-IS Adjacency

- Like OSPF, IS-IS uses hellos to negotiate adjacency parameters
- IS-IS parameters include...
  - NET Address
  - Adjacency Level
  - Network Type
  - Authentication
  - MTU

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS NET Addressing

- OSPF uses IPv4 formatted Router-ID to identify nodes in the LSDB
- IS-IS uses ISO NSAP formatted Network Entity Title (NET) address
- ISO NSAP Addressing Format
  - Maximum 20 bytes
  - Minimum 8 bytes
- Net format  
AA.AAAA.AAAA.AAAA.AAAA.AAAA.AAAA.SSSS.SSSS.SSSS.NN
  - Area – not link-state area like OSPF
  - System-ID - Router-ID inside the area
  - N-Selector - always zero
  - Must be an even number of bytes

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Levels

- OSPF uses areas to define two-level flooding hierarchy
  - Area 0 backbone
  - Non-transit areas
- IS-IS uses “levels” to define two-level flooding hierarchy
  - Level 2 Domain (L2)
  - Level 1 Domain (L1)
- Typically confusing because IS-IS uses both terms
  - Router itself is in the area
  - Level exists on the link
- Routers can participate in L1, L2, or both (L1/L2)

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Level 2 Domain

- Like area 0 in OSPF
- Must be contiguous
  - Cisco IOS does not support IS-IS virtual links
- Links running L2 can form inter-area or intra-area adjacency
  - NET address defines the router's area

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Level 1 Domain

- Like non-transit area in OSPF
- Links running L1 can form intra-area adjacency only
- Routers with all links in L1 (L1 only routers) behave like OSPF Not-So-Totally Stubby area
  - Intra-area routes
  - Default route out
  - Redistribution allowed

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



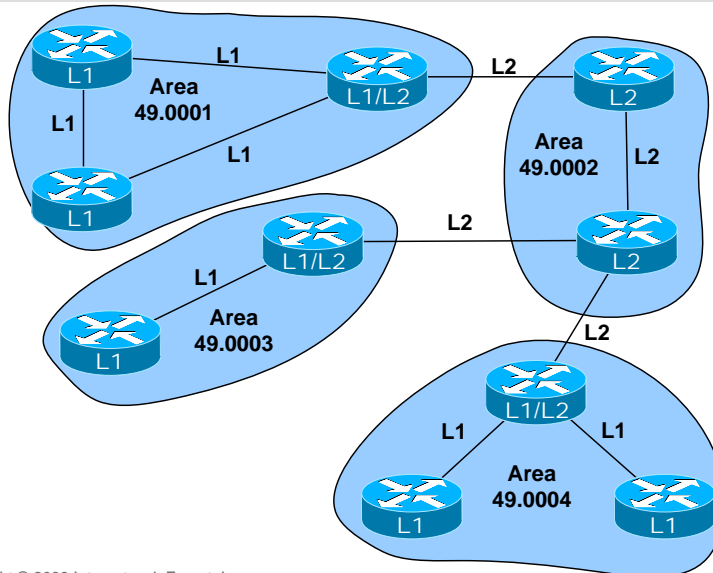
## Level 1 / Level 2 Routing

- Routers running Level 1 and Level 2 (L1/L2 Routers) behave like OSPF ABRs
- Used as an exit point from Level 1 into Level 2
- Advertise a default route into Level 1
  - IS-IS “attached bit”
- Cisco IOS level defaults to L1/L2
  - Can be modified globally or per link

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Level Hierarchy Example



Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Network Types

- Like OSPF, IS-IS performs differently based on media
- Unlike OSPF, there are only two network types
  - Broadcast
    - Default on multipoint interfaces
    - Uses DIS instead of DR / BDR
    - Not supported on partial mesh NBMA
      - e.g. Frame-Relay Hub-and-Spoke
  - Point-to-Point
    - Default on point-to-point interfaces

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Designated Intermediate System

- Like OSPF DR, DIS used to reduce adjacency and LSP flooding scaling issues
  - $n$  adjacencies instead of  $n*(n-1)/2$
  - LSPs are flooded to DIS, DIS floods to other neighbors
- Unlike OSPF, no backup DIS
- Preemption can occur
- DIS elected by
  - Highest interface priority
    - Configurable via `isis priority`
  - Highest SNPA address
    - Ethernet MAC address
    - Frame Relay DLCI
  - Highest System-ID
    - Configurable via NET address
- Separate election for L1 and L2

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Implementing Basic IS-IS

- Enable global IS-IS process
  - `router isis [tag]`
- Define NET address
  - `net [address]`
- Define adjacency level
  - Process level `is-type [level-1|level-2-only|level-1-2]`
  - Interface level `isis circuit-type [level-1|level-2-only|level-1-2]`
- Enable interface process
  - Interface level `ip router isis [tag]`

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com





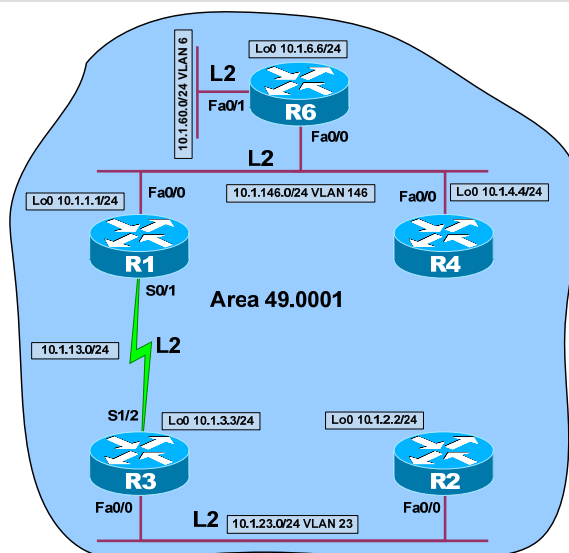
## Verifying IS-IS

- Verify IS-IS neighbors
  - `show clns is-neighbors`
- Verify IS-IS database
  - `show isis database`
  - `show isis database detail`
- Verify IS-IS routing table
  - `show ip route [isis]`

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Implementing Single Level IS-IS



Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Single Level IS-IS Configuration

```

R1#
interface Loopback0
 ip router isis
 !
interface FastEthernet0/0
 ip router isis
 !
interface Serial0/1
 ip router isis
 !
router isis
 net 49.0001.1111.1111.1111.00
 is-type level-2-only

R2#
interface Loopback0
 ip router isis
 !
interface FastEthernet0/0
 ip router isis
 !
router isis
 net 49.0001.2222.2222.2222.00
 is-type level-2-only

R3#
interface Loopback0
 ip router isis
 !
interface FastEthernet0/0
 ip router isis
 !
interface Serial1/2
 ip router isis
 !
router isis
 net 49.0001.3333.3333.3333.00
 is-type level-2-only

R4#
interface Loopback0
 ip router isis
 !
interface FastEthernet0/0
 ip router isis
 !
router isis
 net 49.0001.4444.4444.4444.00
 is-type level-2-only

R6#
interface Loopback0
 ip router isis
 isis circuit-type level-2-only
 !
interface FastEthernet0/0
 ip router isis
 isis circuit-type level-2-only
 !
interface FastEthernet0/1
 ip router isis
 isis circuit-type level-2-only
 !
router isis
 net 49.0001.6666.6666.6666.00

```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Single Level IS-IS Verification

```

R1#show clns is-neighbors

System Id      Interface    State  Type  Priority  Circuit Id  Format
R3             Se0/1       Up     L2    0         00          Phase V
R4             Fa0/0       Up     L2    64        R6.01      Phase V
R6             Fa0/0       Up     L2    64        R6.01      Phase V

R2#show clns is-neighbors

System Id      Interface    State  Type  Priority  Circuit Id  Format
R3             Fa0/0       Up     L2    64        R2.02      Phase V

R3#show clns is-neighbors

System Id      Interface    State  Type  Priority  Circuit Id  Format
R1             Se1/2       Up     L2    0         00          Phase V
R2             Fa0/0       Up     L2    64        R2.02      Phase V

R4#show clns is-neighbors

System Id      Interface    State  Type  Priority  Circuit Id  Format
R1             Fa0/0       Up     L2    64        R6.01      Phase V
R6             Fa0/0       Up     L2    64        R6.01      Phase V

R6#show clns is-neighbors

System Id      Interface    State  Type  Priority  Circuit Id  Format
R1             Fa0/0       Up     L2    64        R6.01      Phase V
R4             Fa0/0       Up     L2    64        R6.01      Phase V

```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Single Level IS-IS Verification (cont.)

R1#show isis database

IS-IS Level-2 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
R1.00-00	* 0x00000005	0x5027	1097	0/0/0
R2.00-00	0x00000004	0x6437	1181	0/0/0
R2.02-00	0x00000002	0xAC63	1032	0/0/0
R3.00-00	0x00000005	0x8102	1096	0/0/0
R4.00-00	0x00000005	0xEBC2	1048	0/0/0
R6.00-00	0x00000006	0x7A82	1123	0/0/0
R6.01-00	0x00000002	0xB3D0	1084	0/0/0

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Single Level IS-IS Verification (cont.)

R1#show isis database detail

IS-IS Level-2 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
R1.00-00	* 0x00000005	0x5027	1094	0/0/0
Area Address: 49.0001 NLPID: 0xCC Hostname: R1 IP Address: 10.1.1.1 Metric: 10 IS R3.00 Metric: 10 IS R6.01 Metric: 10 IP 10.1.1.0 255.255.255.0 Metric: 10 IP 10.1.13.0 255.255.255.0 Metric: 10 IP 10.1.146.0 255.255.255.0				
R2.00-00	0x00000004	0x6437	1178	0/0/0
Area Address: 49.0001 NLPID: 0xCC Hostname: R2 IP Address: 10.1.2.2 Metric: 10 IS R2.02 Metric: 10 IP 10.1.2.0 255.255.255.0 Metric: 10 IP 10.1.23.0 255.255.255.0				
R2.02-00	0x00000002	0xAC63	1029	0/0/0
Metric: 0 IS R2.00 Metric: 0 IS R3.00				
R3.00-00	0x00000005	0x8102	1093	0/0/0
Area Address: 49.0001 NLPID: 0xCC Hostname: R3 IP Address: 10.1.3.3 Metric: 10 IS R1.00 Metric: 10 IS R2.02 Metric: 10 IP 10.1.3.0 255.255.255.0 Metric: 10 IP 10.1.13.0 255.255.255.0 Metric: 10 IP 10.1.23.0 255.255.255.0				
R4.00-00	0x00000005	0xEBC2	1044	0/0/0
Area Address: 49.0001 NLPID: 0xCC Hostname: R4 IP Address: 10.1.4.4 Metric: 10 IS R6.01 Metric: 10 IP 10.1.4.0 255.255.255.0 Metric: 10 IP 10.1.146.0 255.255.255.0				
R6.00-00	0x00000006	0x7A82	1119	0/0/0
Area Address: 49.0001 NLPID: 0xCC Hostname: R6 IP Address: 10.1.6.6 Metric: 10 IP 10.1.146.0 255.255.255.0 Metric: 10 IP 10.1.60.0 255.255.255.0 Metric: 10 IP 10.1.6.0 255.255.255.0 Metric: 10 IS R6.01				
R6.01-00	0x00000002	0xB3D0	1080	0/0/0
Metric: 0 IS R6.00 Metric: 0 IS R1.00 Metric: 0 IS R4.00				

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Single Level IS-IS Verification (cont.)

```

R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

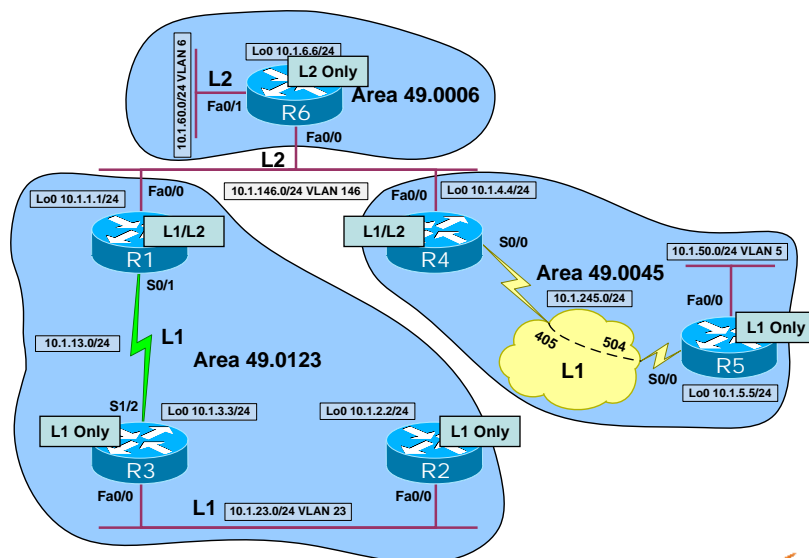
Gateway of last resort is not set

    10.0.0.0/24 is subnetted, 9 subnets
C       10.1.13.0 is directly connected, Serial0/1
i L2    10.1.3.0 [115/20] via 10.1.13.3, Serial0/1
i L2    10.1.2.0 [115/30] via 10.1.13.3, Serial0/1
C       10.1.1.0 is directly connected, Loopback0
i L2    10.1.6.0 [115/20] via 10.1.146.6, FastEthernet0/0
i L2    10.1.4.0 [115/20] via 10.1.146.4, FastEthernet0/0
i L2    10.1.23.0 [115/20] via 10.1.13.3, Serial0/1
i L2    10.1.60.0 [115/20] via 10.1.146.6, FastEthernet0/0
C       10.1.146.0 is directly connected, FastEthernet0/0
    
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Implementing Multi Level IS-IS



Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Configuration

```

R1#
interface Loopback0
ip router isis
isis circuit-type level-1
!
interface FastEthernet0/0
ip router isis
isis circuit-type level-2-only
!
interface Serial0/1
ip router isis
isis circuit-type level-1
!
router isis
net 49.0123.1111.1111.1111.00

R2#
interface Loopback0
ip router isis
!
interface FastEthernet0/0
ip router isis
!
router isis
net 49.0123.2222.2222.2222.00
is-type level-1

R3#
interface Loopback0
ip router isis
!
interface FastEthernet0/0
ip router isis
!
interface Serial1/2
ip router isis
!
router isis
net 49.0123.3333.3333.3333.00
is-type level-1

R4#
interface Loopback0
ip router isis
isis circuit-type level-2-only
!
interface FastEthernet0/0
ip router isis
isis circuit-type level-2-only
!
interface Serial0/0
frame-relay map clns 405 broadcast
ip router isis
isis circuit-type level-1
!
router isis
net 49.0045.4444.4444.4444.00

R5#
interface Loopback0
ip router isis
!
interface FastEthernet0/0
ip router isis
!
interface Serial0/0
frame-relay map clns 504 broadcast
ip router isis
!
router isis
net 49.0045.5555.5555.5555.00
is-type level-1

R6#
interface Loopback0
ip router isis
!
interface FastEthernet0/0
ip router isis
!
interface FastEthernet0/1
ip router isis
!
router isis
net 49.0006.6666.6666.6666.00
is-type level-2-only

```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification

```

R1#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R3             Se0/1     Up     L1   0          00             Phase V
R4             Fa0/0     Up     L2   64         R6.02          Phase V
R6             Fa0/0     Up     L2   64         R6.02          Phase V

R2#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R3             Fa0/0     Up     L1   64         R2.02          Phase V

R3#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R1             Se1/2     Up     L1   0          00             Phase V
R2             Fa0/0     Up     L1   64         R2.02          Phase V

R4#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R1             Fa0/0     Up     L2   64         R6.02          Phase V
R5             Se0/0     Up     L1   64         R5.03          Phase V
R6             Fa0/0     Up     L2   64         R6.02          Phase V

R5#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R4             Se0/0     Up     L1   64         R5.03          Phase V

R6#show clns is-neighbors

System Id      Interface  State  Type Priority  Circuit Id      Format
R1             Fa0/0     Up     L2   64         R6.02          Phase V
R4             Fa0/0     Up     L2   64         R6.02          Phase V

```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

R1#show isis database

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      * 0x00000003  0xA3DD      783          1/0/0
R2.00-00      0x00000003  0xC6B4      765          0/0/0
R2.02-00      0x00000001  0x1D6D      766          0/0/0
R3.00-00      0x00000003  0x9EC5      768          0/0/0
```

```
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      * 0x00000005  0x4F8F      793          0/0/0
R4.00-00      0x00000005  0xB111      847          0/0/0
R4.02-00      0x00000001  0x263A      0 (793)     0/0/0
R6.00-00      0x00000002  0x28D2      792          0/0/0
R6.02-00      0x00000001  0xAED5      792          0/0/0
```

R2#show isis database

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      0x00000003  0xA3DD      777          1/0/0
R2.00-00      * 0x00000003  0xC6B4      767          0/0/0
R2.02-00      * 0x00000001  0x1D6D      768          0/0/0
R3.00-00      0x00000003  0x9EC5      766          0/0/0
```

R3#show isis database

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      0x00000003  0xA3DD      778          1/0/0
R2.00-00      0x00000003  0xC6B4      764          0/0/0
R2.02-00      0x00000001  0x1D6D      765          0/0/0
R3.00-00      * 0x00000003  0x9EC5      767          0/0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

R4#show isis database

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R4.00-00      * 0x00000004  0x7F9C      839          1/0/0
R5.00-00      0x00000002  0x250F      837          0/0/0
R5.03-00      0x00000001  0x4973      837          0/0/0
```

```
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      0x00000005  0x4F8F      786          0/0/0
R4.00-00      * 0x00000005  0xB111      844          0/0/0
R4.02-00      * 0x00000001  0x263A      0 (788)     0/0/0
R6.00-00      0x00000002  0x28D2      788          0/0/0
R6.02-00      0x00000001  0xAED5      788          0/0/0
```

R5#show isis database

```
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R4.00-00      0x00000004  0x7F9C      835          1/0/0
R5.00-00      * 0x00000002  0x250F      836          0/0/0
R5.03-00      * 0x00000001  0x4973      837          0/0/0
```

R6#show isis database

```
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00      0x00000005  0x4F8F      783          0/0/0
R4.00-00      0x00000005  0xB111      839          0/0/0
R4.02-00      0x00000001  0x263A      0 (785)     0/0/0
R6.00-00      * 0x00000002  0x28D2      787          0/0/0
R6.02-00      * 0x00000001  0xAED5      787          0/0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

```

R1#show isis database detail
IS-IS Level-1 Link State Database:
LSPID      LSP Seq Num  LSP Checksum LSP Holdtime  ATT/P/OL
R1.00-00   * 0x00000003 0xA3DD       766           1/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R1
IP Address: 10.1.1.1
Metric: 10   IP 10.1.13.0 255.255.255.0
Metric: 10   IP 10.1.1.0 255.255.255.0
Metric: 10   IS R3.00
R2.00-00   * 0x00000003 0xC6B4       748           0/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R2
IP Address: 10.1.2.2
Metric: 10   IP 10.1.23.0 255.255.255.0
Metric: 10   IP 10.1.2.0 255.255.255.0
Metric: 10   IS R2.02
R2.02-00   * 0x00000001 0xD6D        749           0/0/0
Metric: 0    IS R2.00
Metric: 0    IS R3.00
R3.00-00   * 0x00000003 0x9EC5       751           0/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R3
IP Address: 10.1.3.3
Metric: 10   IP 10.1.23.0 255.255.255.0
Metric: 10   IP 10.1.13.0 255.255.255.0
Metric: 10   IP 10.1.3.0 255.255.255.0
Metric: 10   IS R1.00
Metric: 10   IS R2.02
IS-IS Level-2 Link State Database:
LSPID      LSP Seq Num  LSP Checksum LSP Holdtime  ATT/P/OL
R1.00-00   * 0x00000005 0x4F8F       775           0/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R1
IP Address: 10.1.146.1
Metric: 10   IP 10.1.146.0 255.255.255.0
Metric: 10   IS R6.02
Metric: 10   IP 10.1.1.0 255.255.255.0
Metric: 10   IP 10.1.2.0 255.255.255.0
Metric: 20   IP 10.1.3.0 255.255.255.0
Metric: 10   IP 10.1.13.0 255.255.255.0
Metric: 10   IP 10.1.23.0 255.255.255.0
R4.00-00   0x00000005 0xB111       828           0/0/0
Area Address: 49.0045
NLPID: 0xCC
Hostname: R4
IP Address: 10.1.4.4
Metric: 10   IP 10.1.146.0 255.255.255.0
Metric: 10   IP 10.1.4.0 255.255.255.0
Metric: 10   IS R6.02
Metric: 20   IP 10.1.5.0 255.255.255.0
Metric: 20   IP 10.1.50.0 255.255.255.0
Metric: 10   IP 10.1.245.0 255.255.255.0
R4.02-00   0x00000001 0x263A       0 (774)       0/0/0
R6.00-00   0x00000002 0x2BD2       773           0/0/0
Area Address: 49.0006
NLPID: 0xCC
Hostname: R6
IP Address: 10.1.6.6
Metric: 10   IS R6.02
Metric: 10   IP 10.1.6.0 255.255.255.0
Metric: 10   IP 10.1.60.0 255.255.255.0
Metric: 10   IP 10.1.146.0 255.255.255.0
R6.02-00   0x00000001 0xA8D5       773           0/0/0
Metric: 0    IS R6.00
Metric: 0    IS R1.00
Metric: 0    IS R4.00
    
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

```

R2#show isis database detail
IS-IS Level-1 Link State Database:
LSPID      LSP Seq Num  LSP Checksum LSP Holdtime  ATT/P/OL
R1.00-00   0x00000003 0xA3DD       757           1/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R1
IP Address: 10.1.1.1
Metric: 10   IP 10.1.13.0 255.255.255.0
Metric: 10   IP 10.1.1.0 255.255.255.0
Metric: 10   IS R3.00
R2.00-00   * 0x00000003 0xC6B4       747           0/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R2
IP Address: 10.1.2.2
Metric: 10   IP 10.1.23.0 255.255.255.0
Metric: 10   IP 10.1.2.0 255.255.255.0
Metric: 10   IS R2.02
R2.02-00   * 0x00000001 0xD6D        748           0/0/0
Metric: 0    IS R2.00
Metric: 0    IS R3.00
R3.00-00   0x00000003 0x9EC5       747           0/0/0
Area Address: 49.0123
NLPID: 0xCC
Hostname: R3
IP Address: 10.1.3.3
Metric: 10   IP 10.1.23.0 255.255.255.0
Metric: 10   IP 10.1.13.0 255.255.255.0
Metric: 10   IP 10.1.3.0 255.255.255.0
Metric: 10   IS R1.00
Metric: 10   IS R2.02
    
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/24 is subnetted, 12 subnets
C    10.1.13.0 is directly connected, Serial0/1
i L1 10.1.2.0 [115/20] via 10.1.13.3, Serial0/1
i L1 10.1.2.0 [115/30] via 10.1.13.3, Serial0/1
C    10.1.1.0 is directly connected, Loopback0
i L2 10.1.6.0 [115/20] via 10.1.146.6, FastEthernet0/0
i L2 10.1.5.0 [115/30] via 10.1.146.4, FastEthernet0/0
i L2 10.1.4.0 [115/20] via 10.1.146.4, FastEthernet0/0
i L1 10.1.23.0 [115/20] via 10.1.13.3, Serial0/1
i L2 10.1.60.0 [115/20] via 10.1.146.6, FastEthernet0/0
i L2 10.1.50.0 [115/30] via 10.1.146.4, FastEthernet0/0
C    10.1.146.0 is directly connected, FastEthernet0/0
i L2 10.1.245.0 [115/20] via 10.1.146.4, FastEthernet0/0

R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.23.3 to network 0.0.0.0

10.0.0.0/24 is subnetted, 5 subnets
i L1 10.1.13.0 [115/20] via 10.1.23.3, FastEthernet0/0
i L1 10.1.2.0 [115/20] via 10.1.23.3, FastEthernet0/0
C    10.1.2.0 is directly connected, Loopback0
i L1 10.1.1.0 [115/30] via 10.1.23.3, FastEthernet0/0
C    10.1.23.0 is directly connected, FastEthernet0/0
i*L1 0.0.0.0/0 [115/10] via 10.1.23.3, FastEthernet0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## Multi Level IS-IS Verification (cont.)

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.13.1 to network 0.0.0.0

10.0.0.0/24 is subnetted, 5 subnets
C    10.1.13.0 is directly connected, Serial1/2
i L1 10.1.2.0 [115/20] via 10.1.23.2, FastEthernet0/0
i L1 10.1.1.0 [115/20] via 10.1.13.1, Serial1/2
C    10.1.23.0 is directly connected, FastEthernet0/0
i*L1 0.0.0.0/0 [115/10] via 10.1.13.1, Serial1/2

R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/24 is subnetted, 12 subnets
i L2 10.1.13.0 [115/20] via 10.1.146.1, FastEthernet0/0
i L2 10.1.3.0 [115/30] via 10.1.146.1, FastEthernet0/0
i L2 10.1.2.0 [115/40] via 10.1.146.1, FastEthernet0/0
i L2 10.1.1.0 [115/20] via 10.1.146.1, FastEthernet0/0
i L2 10.1.6.0 [115/20] via 10.1.146.6, FastEthernet0/0
i L1 10.1.5.0 [115/20] via 10.1.245.5, Serial0/0
C    10.1.4.0 is directly connected, Loopback0
i L2 10.1.23.0 [115/30] via 10.1.146.1, FastEthernet0/0
i L2 10.1.60.0 [115/20] via 10.1.146.6, FastEthernet0/0
i L1 10.1.50.0 [115/20] via 10.1.245.5, Serial0/0
C    10.1.146.0 is directly connected, FastEthernet0/0
C    10.1.245.0 is directly connected, Serial0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com





## Multi Level IS-IS Verification (cont.)

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.245.4 to network 0.0.0.0

10.0.0.0/24 is subnetted, 3 subnets
C    10.1.5.0 is directly connected, Loopback0
C    10.1.50.0 is directly connected, FastEthernet0/0
C    10.1.245.0 is directly connected, Serial0/0
i*L1 0.0.0.0/0 [115/10] via 10.1.245.4, Serial0/0

R6#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        NL - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/24 is subnetted, 12 subnets
i L2 10.1.13.0 [115/20] via 10.1.146.1, FastEthernet0/0
i L2 10.1.3.0 [115/30] via 10.1.146.1, FastEthernet0/0
i L2 10.1.2.0 [115/40] via 10.1.146.1, FastEthernet0/0
i L2 10.1.1.0 [115/20] via 10.1.146.1, FastEthernet0/0
C    10.1.6.0 is directly connected, Loopback0
i L2 10.1.5.0 [115/30] via 10.1.146.4, FastEthernet0/0
i L2 10.1.4.0 [115/20] via 10.1.146.4, FastEthernet0/0
i L2 10.1.23.0 [115/30] via 10.1.146.1, FastEthernet0/0
C    10.1.60.0 is directly connected, FastEthernet0/1
i L2 10.1.50.0 [115/30] via 10.1.146.4, FastEthernet0/0
C    10.1.146.0 is directly connected, FastEthernet0/0
i L2 10.1.245.0 [115/20] via 10.1.146.4, FastEthernet0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Path Selection & Metric Styles

- OSPF uses bandwidth based cost
  - Higher bandwidth, lower cost
- IS-IS uses flat cost of 10 for all links
  - Configurable via `isis metric` per link
- Metric “style” controls range of cost value as well as extensibility
  - Narrow
    - Maximum cost of 63 per link
  - Wide
    - Maximum cost of  $2^{24}$
    - Supports new TLV for extensibility
      - e.g. MPLS Traffic Engineering
  - Transition
    - Use both old and new TLVs
- Neighbors must agree on metric style or LSPs learned cannot be used
  - Process level `metric-style [narrow|wide|transition]`

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Summarization

- Like OSPF, allowed only between levels or at redistribution
- Process level **summary-address** **[network] [mask]**

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Summarization Example

```
R1#
router isis
 summary-address 10.1.2.0 255.255.254.0

R6#show ip route isis
 10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks
i L2 10.1.13.0/24 [115/20] via 10.1.146.1, FastEthernet0/0
i L2 10.1.2.0/23 [115/30] via 10.1.146.1, FastEthernet0/0
i L2 10.1.1.0/24 [115/20] via 10.1.146.1, FastEthernet0/0
i L2 10.1.5.0/24 [115/30] via 10.1.146.4, FastEthernet0/0
i L2 10.1.4.0/24 [115/20] via 10.1.146.4, FastEthernet0/0
i L2 10.1.23.0/24 [115/30] via 10.1.146.1, FastEthernet0/0
i L2 10.1.50.0/24 [115/30] via 10.1.146.4, FastEthernet0/0
i L2 10.1.245.0/24 [115/20] via 10.1.146.4, FastEthernet0/0

R6#show ip route 10.1.2.2
Routing entry for 10.1.2.0/23
  Known via "isis", distance 115, metric 30, type level-2
  Redistributing via isis
  Last update from 10.1.146.1 on FastEthernet0/0, 00:00:10 ago
  Routing Descriptor Blocks:
    * 10.1.146.1, from 10.1.146.1, via FastEthernet0/0
      Route metric is 30, traffic share count is 1

R6#show ip route 10.1.3.3
Routing entry for 10.1.2.0/23
  Known via "isis", distance 115, metric 30, type level-2
  Redistributing via isis
  Last update from 10.1.146.1 on FastEthernet0/0, 00:00:12 ago
  Routing Descriptor Blocks:
    * 10.1.146.1, from 10.1.146.1, via FastEthernet0/0
      Route metric is 30, traffic share count is 1
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Route Leaking

- Normally no routes pass from Level-2 into Level-1, and all routes pass from Level-1 into Level-2
- Route leaking used to...
  - Allow prefixes from Level-2 into Level-1
  - Filter prefixes from Level-1 into Level-2
- Configured under L1/L2 router's process
  - `redistribute isis ip level-1 into level-2 [distribute-list|route-map]`
  - `redistribute isis ip level-1 into level-2 [distribute-list|route-map]`

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Route Leaking Example

```
R4#
access-list 100 permit ip host 10.1.4.0 host 255.255.255.0
access-list 100 permit ip host 10.1.6.0 host 255.255.255.0
access-list 100 permit ip host 10.1.1.0 host 255.255.255.0
!
router isis
 redistribute isis ip level-2 into level-1 distribute-list 100

R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.245.4 to network 0.0.0.0

10.0.0.0/24 is subnetted, 6 subnets
i ia  10.1.1.0 [115/158] via 10.1.245.4, Serial0/0
i ia  10.1.6.0 [115/158] via 10.1.245.4, Serial0/0
C     10.1.5.0 is directly connected, Loopback0
i ia  10.1.4.0 [115/148] via 10.1.245.4, Serial0/0
C     10.1.50.0 is directly connected, FastEthernet0/0
C     10.1.245.0 is directly connected, Serial0/0
i*L1 0.0.0.0/0 [115/10] via 10.1.245.4, Serial0/0
```

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Authentication

- IS-IS supports two types of authentication
  - Plain text LSP authentication
    - Level-1 area password
    - Level-2 domain password
  - Plain text and MD5 adjacency authentication
    - Key-chain based like RIPv2 & EIGRP
- Plain text authentication does not stop routers from becoming adjacent, but does prevent against route injection
  - More to avoid misconfiguration than for security

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Authentication Examples

```
R1#
key chain ISIS
key 1
  key-string CISCO
!
interface Serial0/1
isis authentication mode md5
isis authentication key-chain ISIS
```

```
R3#key chain ISIS
key 1
  key-string CISCO
!
interface Serial1/2
isis authentication mode md5
isis authentication key-chain ISIS
```

```
R3#show clns is-neighbors
```

System Id	Interface	State	Type	Priority	Circuit Id	Format
R1	Se1/2	Up	L1	0	00	Phase V
R2	Fa0/0	Up	L1	64	R2.02	Phase V

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Tuning

- Like OSPF, IS-IS database calculation & lookup times a function of hardware
  - e.g. faster CPU, more memory, faster lookups
- Resource needs can be lowered through
  - Levels for flooding domain segmentation
  - Summarization
- Further optimization through timers
  - Hello & dead timers
    - Faster neighbor down detection
  - LSP timers
    - How long do I wait between updates, retransmits, etc.

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com



## IS-IS Q&A

Copyright © 2009 Internetwork Expert, Inc  
www.INE.com

